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# Standard Practice for Monitoring Atmospheric SO<sub>2</sub> Using the Sulfation Plate Technique<sup>1</sup>

This standard is issued under the fixed designation G91; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This practice covers a weighted average effective SO<sub>2</sub> level for a 30-day interval through the use of the sulfation plate method, a technique for estimating the effective SO<sub>2</sub> content of the atmosphere, and especially with regard to the atmospheric corrosion of stationary structures or panels. This practice is aimed at determining SO<sub>2</sub> levels rather than sulfuric acid aerosol or acid precipitation.

1.2 The results of this practice correlate approximately with volumetric SO<sub>2</sub> concentrations, although the presence of dew or condensed moisture tends to enhance the capture of SO<sub>2</sub> into the plate.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

2.1 *ASTM Standards:*<sup>2</sup>

D516 Test Method for Sulfate Ion in Water

D2010/D2010M Test Methods for Evaluation of Total Sulfation Activity in the Atmosphere by the Lead Dioxide Technique

G16 Guide for Applying Statistics to Analysis of Corrosion Data

## 3. Summary of Practice

3.1 Sulfation plates consisting of a lead peroxide reagent in an inverted dish are exposed for 30-day intervals. The plates

<sup>1</sup> This practice is under the jurisdiction of ASTM Committee G01 on Corrosion of Metals and is the direct responsibility of Subcommittee G01.04 on Atmospheric Corrosion.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

are recovered and sulfate analyses performed on the contents to determine the extent of sulfur capture. The results are reported in terms of milligrams of SO<sub>2</sub> per square metre per day.

## 4. Significance and Use

4.1 Atmospheric corrosion of metallic materials is a function of many weather and atmospheric variables. The effect of specific corrodants, such as sulfur dioxide, can accelerate the atmospheric corrosion of metals significantly. The sulfation plate method provides a simple technique to independently monitor the level of SO<sub>2</sub> in the atmosphere to yield a weighted average result.

4.2 Sulfation plate results may be used to characterize atmospheric corrosion test sites regarding the effective average level of SO<sub>2</sub> in the atmosphere at these locations.

4.3 Sulfation plate testing is useful in determining microclimate, seasonal, and long term variations in the effective average level of SO<sub>2</sub>.

4.4 The results of sulfation plate tests may be used in correlations of atmospheric corrosion rates with atmospheric data to determine the sensitivity of the corrosion rate to SO<sub>2</sub> level.

4.5 The sulfation plate method may also be used with other methods to characterize the atmosphere at sites where buildings or other construction is planned in order to determine the extent of protective measures required for metallic materials.

## 5. Interferences

5.1 The lead peroxide reagent used in this practice may convert other compounds such as mercaptans, hydrogen sulfide, and carbonyl sulfide into sulfate.

NOTE 1—Hydrogen sulfide and mercaptans, at concentrations which affect the corrosion of structural metals significantly, are relatively rare in most atmospheric environments, but their effects regarding the corrosion of metals are not equivalent to sulfur dioxide. Therefore, if H<sub>2</sub>S, COS, or mercaptans are present in the atmosphere, the lead peroxide method must not be used to assess atmospheric corrosivity. It should also be noted that no actual measurements have been made which would establish the correlation between atmospheric H<sub>2</sub>S, COS, or mercaptan level and sulfation as measured by this practice.

5.2 The inverted exposure position of the sulfation plate is intended to minimize capture of sulfuric acid aerosols and sulfur bearing species from precipitation.

## 6. Sulfation Plate Preparation and Exposure

6.1 Sulfation plates can be prepared according to the method of Huey.<sup>3</sup> The plate preparation method is given in **Appendix X1**. Laboratory prepared plates should be exposed within 120 days of preparation.

6.2 In general, the level of atmospheric sulfur dioxide varies seasonally during the year so that a minimal exposure program requires four 30-day exposures each year at roughly equal intervals. In order to establish the atmospheric SO<sub>2</sub> level at an atmospheric corrosion test site which has not been monitored previously, a program in which six 30-day exposures per year for a period of 3 years is recommended. More extensive testing may be desirable if large variability is encountered in the results. Thereafter, the location should be monitored with at least four tests in a 1-year period every 3 years. If the subsequent tests are not consistent with the initial testing, then another 3-year program of six tests per year is required. Also, if a major change in the general area occurs in terms of industrial or urban development, then six tests per year for 3 years should again be carried out.

6.3 In monitoring exposure sites, a minimum of four plates shall be used for each exposure period.

6.3.1 Sites which have a grade or elevation variation should be monitored with at least two plates at the highest elevation and two plates at the lowest elevation.

6.3.2 Plates should be exposed, if possible, at both the highest and lowest level above the ground at which corrosion test specimens are exposed.

6.3.3 Sites larger than 10 000 m<sup>2</sup> shall have at least eight plates exposed for each period. In rectangular sites on level ground, it is desirable to expose two plates at each corner.

**NOTE 2**—Some investigators have reported significantly higher sulfation results at locations closest to the ground.

6.4 Brackets shall be used to hold the plates securely in an inverted position so that the lead peroxide mixture faces downward. The plate shall be horizontal and shall be placed so that it is not protected from normal winds and air currents. The bracket design should include a retaining clip or other provision to hold the plate in the event of strong winds. The retainer clip may be made from stainless steel, spring bronze, hard aluminum alloy (3003H19), or other alloys with sufficient strength and atmospheric corrosion resistance. A typical bracket design is shown in **Fig. 1**.

6.5 A30 ± 2-day exposure period is recommended. At the conclusion of this period, the plates should be removed from the bracket and covered tightly to prevent additional sulfation. Analysis of the plates should be completed within 60 days of the completion of the exposure. The plate identification, exposure location, and exposure initiation date should be

recorded when the plate exposure is initiated. At the termination of exposure, the completion date should be added to the exposure records.

**NOTE 3**—The 30 day exposure is not very discriminating in areas of low SO<sub>2</sub> concentrations. Experience has shown that 60- to 90-day exposure may be necessary to develop a measurable SO<sub>2</sub> capture on the plate.

6.6 The sulfation plates shall be analyzed for sulfate content using any established quantitative analysis technique.

**NOTE 4**—In conducting the sulfate analysis, it is necessary to remove the contents of the sulfation plate and solubilize the sulfate, for example, using a solution of sodium carbonate. It has been found that 20 mL of 50 g/L Na<sub>2</sub>CO<sub>3</sub> (ACS reagent grade) is sufficient to solubilize the sulfate in this test method in a 3-hour period. Thereafter, conventional sulfate analysis can be employed, for example, by barium precipitation and either gravimetric or turbidimetric analysis (see Test Methods **D516**).

## 7. Calculation

7.1 The sulfate analysis provides the quantity of sulfate on each disc analyzed. This should be converted to an SO<sub>2</sub> capture rate, *R*, by the following equation.

$$R = (m - m_0) \times MWSO_2 / MWSO_4 \times A \times T \quad (1)$$

where:

- m* = mass of sulfate found in the plate, mg,
- m*<sub>0</sub> = mass of sulfate found in a blank (unexposed) plate, mg,
- MWSO*<sub>2</sub> = 64,
- MWSO*<sub>4</sub> = 96,
- A* = area of the plate, m<sup>2</sup>, and
- T* = exposure time of the plate, days.

$$R = SO_2 \text{ capture rate, mg SO}_2/\text{m}^2 \text{ day} \quad (2)$$

7.2 The SO<sub>2</sub> capture rate may be converted to equivalent SO<sub>3</sub> or SO<sub>4</sub> values if desired, but for comparison purposes, SO<sub>2</sub> rates shall be used.

7.3 The average value and standard deviation of the values should be calculated according to **Guide G16**.

## 8. Report

8.1 The report shall include the following information:

8.1.1 A description of the exposure site and the locations where the plates were exposed, including the bracket identity number or designation and the location on the exposure stand,

8.1.2 The exposure initiation and termination dates,

8.1.3 The identification numbers and sources of the sulfation plates,

8.1.4 The calculated SO<sub>2</sub> capture rates for each plate and the average and standard deviations for each site and exposure interval,

8.1.5 The sulfate analysis method, and

8.1.6 Any deviations from this practice.

8.2 Comparison should be made to previously determined values in ongoing monitoring programs.

## 9. Precision and Bias

9.1 Repeatability for a group of plates prepared in one batch and exposed for 30 days under essentially identical conditions,

<sup>3</sup> Huey, N. A., "The Lead Dioxide Estimation of Sulfur Dioxide Pollution," *Journal of the Air Pollution Control Association*, Vol 18, No. 9, 1968, pp. 610–611.